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# Economic Statistics for NOAA

*March 2003—Revised Edition*

**U.S. Department of Commerce**  
National Oceanic and Atmospheric Administration



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## Forward

This is the first revision to **Economic Statistics for NOAA**, a compendium of economic statistics relevant to NOAA's mission and programs. It is intended to serve as a common reference to the economic impacts and benefits of NOAA programs and provide a consistent set of economic statistics for NOAA management and staff when preparing for Congressional visits and testimony, budget preparation, speeches, and other external events.

Two criteria were established for inclusion. The first is relevance and importance to NOAA's mission and activities. Second is the ability to cite a credible source in either peer-reviewed or gray literature or correspondence.

Statistics are grouped into three general categories.

- **Economic and Social Impacts** reflect how natural marine, atmospheric, and coastal phenomena affect the general public. For example, weather and climate sensitive industries account for nearly 30 percent of the Nation's GDP.
- **Contributions to U.S. Income, Employment, and Output** are statistics that directly reflect the market value and human uses of resources impacted by NOAA's programs. For example, the economic value added to the national economy by the U.S. commercial fishing industry was approximately \$29 billion in 2001. Other statistics are a direct measure of the economic benefits of investing in NOAA programs, such as improvements in El Niño forecasts.
- **Values and Uses of Coastal Ocean Natural Resources** statistics illustrate the demographic, social, and economic importance of the Nation's coastal areas. They also reflect the quantitative importance of so-called "nonmarket" benefits of coastal resources such as beaches and recreational boating, which are not directly measured in dollar terms.

**Economic Statistics for NOAA** is noteworthy in that it illustrates the economic importance of NOAA's programs to the Nation's economy and public well-being. This revised edition includes additional statistics, especially on severe weather impacts, fisheries, Sea Grant, economic benefits of weather and climate forecasting, and ocean observing systems.

**Economic Statistics for NOAA** was prepared with the assistance and input of staff throughout NOAA. Margaret Fowke and Jerry Slaff provided particularly valuable assistance in this revision.

The NOAA Library (<http://www.lib.noaa.gov>) serves as the repository for information in this publication. Questions and comments should be directed to NOAA Chief Economist Dr. Rodney Weiher by e-mail at [rodney.f.weiher@noaa.gov](mailto:rodney.f.weiher@noaa.gov), or by phone at (202) 482-5181.

A handwritten signature in black ink, reading "C. Lautenbacher, Jr." with a stylized, cursive script.

Vice Admiral Conrad C. Lautenbacher Jr. (USN-ret.)  
Under Secretary of Commerce for Oceans and Atmosphere  
Administrator, National Oceanic and Atmospheric Administration  
Washington, DC

*March 2003*

## **Economic and Social Impacts**



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## Weather and Climate Impacts

Weather and climate sensitive industries, both directly and indirectly, account for about one-third of the Nations' GDP, or \$3 trillion, ranging from finance, insurance, and real estate to services, retail and wholesale trade and manufacturing.

**Cite:** Dutton, John A., *Opportunities and priorities in a new era for weather and climate services*, Bulletin of the American Meteorological Society, September 2002, pp 1303-1311.

Industries directly impacted by weather such as agriculture, construction, energy distribution, and outdoor recreation account for nearly 10 percent of GDP.

**Cite:** U.S. Department of Commerce, National Oceanic and Atmospheric Administration, *The economic implications of an El Niño*. NOAA Magazine Online, March 6, 2002, available only online at: <http://www.noaanews.noaa.gov/magazine/stories/mag24.htm>.

Drought is estimated to result in average annual losses to all sectors of the economy of between \$6-8 billion.

**Cite:** Federal Emergency Management Administration, Mitigation Directorate. 1995, *National Mitigation Strategy Partnerships for Building Safer Communities*, Washington, D.C. Online version available at <http://www.app1.fema.gov/mit/ntmstrat.htm>.

Although drought does not have major impacts on the overall viability of U.S. agriculture it does impose costs on regional and local agricultural economies. The 1999 drought, for example, led to farm net income losses of approximately \$1.35 billion. Areas of the Northeast encountering extreme and severe drought bore 62 percent of these losses. Farm net income losses were equivalent to only three percent of the U.S.'s expected net farm income for 1999; however, 25 percent of U.S. harvested cropland and 32 percent of pastureland were affected.

**Cite:** *Economic Impacts of Drought and the Benefits of NOAA's Drought Forecasting Services*, NOAA Magazine, September 17, 2002. Website: <http://www.noaanews.noaa.gov/magazine/stories/mag51.htm>.

Severe fire seasons due to drought and frequent winds can result in billions of dollars in damages. The Western Fire Season Spring-Summer 2000 resulted in nearly seven million acres burned and an estimated \$2 billion in damage costs (includes fire suppression).

**Cite:** *Economic Impacts of Drought and the Benefits of NOAA's Drought Forecasting Services*, NOAA Magazine, September 17, 2002. Website: <http://www.noaanews.noaa.gov/magazine/stories/mag51.htm>.



Average annual damage from tornadoes, hurricanes, and floods is \$11.4 billion, of which:

- hurricanes average \$5.1 billion and 20 deaths per year;
- floods account for \$5.2 billion, and average over 80 deaths per year,
- tornadoes cause \$1.1 billion in damages.

**Cite:** National Center for Atmospheric Research (NCAR), Environmental and Societal Impacts Group, and the Atmospheric Policy Program of the American Meteorological Society, 2001, *Extreme Weather Sourcebook 2001: Economic and Other Societal Impacts Related to Hurricanes, Floods, Tornadoes, Lightning, and Other U.S. Weather Phenomena*, National Center for Atmospheric Research, Boulder, Colo. Available only online at <http://sciencepolicy.colorado.edu/sourcebook/data.html>

The costliest U.S. hurricane was in 1926 in Miami, causing \$90 billion in damage (in 2000 dollars). By contrast, Hurricane Andrew (1992) caused \$40 billion (in 2000 dollars).

**Cite:** Jarrell, Jerry D., Landsea, Christopher W., Mayfield, Max, and Rappaport, Edward N. October 2001 update, *The Deadliest, Costliest, and Most Intense United States Hurricanes from 1900 to 2000 (and Other Frequently Requested Hurricane Facts)*, NOAA Technical Memorandum NWS TPC-1. Hurricane Research Division, Miami, Fl. Available online at: <http://www.aoml.noaa.gov/hrd/Landsea/deadly/>

In 2001, severe weather caused \$11.8 billion in damages. Weather-related injuries showed a slight downward trend in 2001, dropping to 2,718 from 2,796 in 2000.

**Cite:** 2001 U.S. Natural Hazard Statistics Report, Summary of Natural Hazard Statistics for 2001 in the United States, updated Nov. 25, 2002. Website: <http://www.nws.noaa.gov/om/hazstats.shtml>.

\$6 billion annually is lost in economic efficiencies as a result of air traffic delays, of which 70 percent is attributed to weather.

**Cite:** 2002 State of the U.S. Airline Industry: A Report on Recent Trends for U.S. Carriers, Air Transport Association, Washington, D.C., 2002. Website: <http://www.airlines.org/public/industry/display1.asp?nid=1026>

Lightning causes \$4 to 5 billion in losses each year in the civilian sector.

**Cite:** Kithil, R., *21st Century Lightning Safety for Facilities & Structures*, Presented at the International Lightning Detection Conference, Tucson, Ariz., October, 2002.

Lightning has consistently been one of the top three causes of weather-related deaths in the country. It kills approximately 100 people and injures hundreds more each year.

**Cite:** *National Athletic Trainers' Association Position Statement: Lightning Safety for Athletics and Recreation*, Journal of Athletic Training, Vol. 35, No. 4, December 2000.

Lightning costs about \$2 billion annually in airline operating costs and passenger delays.

**Cite:** Northeast States Emergency Consortium, Wakefield, Mass., 2002. <http://www.serve.com/NESEC>.

The costliest U.S. tornado outbreak caused nearly \$1.6 billion in insured losses on May 3-7, 1999, with the greatest losses in the Oklahoma City, Okla. area.

**Cite:** Insurance Information Institute, 2002. <http://www.disasterinformation.org>

During 1980-2002, the U.S. sustained 54 weather- or climate-related disasters, with damages and costs exceeding \$1 billion per event. Total inflation-adjusted direct losses from these events were more than \$300 billion.

**Cite:** *Billion Dollar U.S. Weather Disasters, 1980-2002*. Tom Ross and Neal Lott, NOAA National Climatic Data Center, 2003. Website: <http://www.ncdc.noaa.gov/oa/reports/billionz.html>

#### Other Extreme Weather:

- The costliest U.S. drought of the past forty years occurred in 1988 and caused more than \$56 billion (in 2000 dollars) of economic losses. More than 5,000 heat-related deaths were also attributed to the heat wave associated with that event.
- The costliest U.S. flood event occurred in the Midwest during the summer of 1993, resulting in approximately \$24 billion in losses (in 2000 dollars) and 48 fatalities.
- The costliest U.S. wildfire of the past forty years occurred in October 1991 in Oakland, Calif., resulting in more than \$3 billion in losses (in 2000 dollars) and 25 deaths.
- Two of the most costly ice storms in U.S. history occurred during the 1990's—in the northeast in January 1998 (more than \$1.4 billion) and in the southeast in February 1994 (more than \$3 billion).

**Cite:** Lott, N. and T. Ross, *A Climatology of Recent Extreme Weather and Climate Events*, NCDC Technical Report 2000-02, Asheville, N.C., NOAA National Climatic Data Center, 2000.

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## El Niño Impacts

Overall, the 1997-1998 El Niño is estimated to have had total U.S. economic impacts on the order of \$25 billion.

**Cite:** Changnon, Stanley A., ed. *El Niño 1997-1998: The Climate Event of the Century*, Oxford University Press, 2000.

Property losses were \$2.6 billion; crop losses approached \$2 billion.

**Cite:** Changnon, Stanley A., ed. *El Niño 1997-1998: The Climate Event of the Century*, Oxford University Press, 2000, p. 144 and p. 201.

Weiher, Rodney F. (ed.), *Improving El Niño Forecasting: The Potential Economic Benefits*, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Policy and Strategic Planning, Washington, D.C. (2000), p. 18.

California storm losses in the 1997-98 El Niño were \$1.1 billion.

**Cite:** Changnon, Stanley A., ed. *El Niño 1997-1998: The Climate Event of the Century*, Oxford University Press, 2000, p. 22.

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## NOTES

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## Coastal Storm Impacts

Coastal storms account for 71 percent of recent U.S. disaster losses annually. Each event costs roughly \$500 million. With 14 events in a year, losses would total \$7 billion per year.

**Cite:** The H. John Heinz III Center for Science Economics and the Environment, *The Hidden Costs of Coastal Hazards: Implications for Risk Assessment and Mitigation*, Island Press, 2000, Washington, D.C.

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### NOTES

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## Harmful Algal Bloom (HAB) Impacts

Economic impact of HABs in United States average annually \$49 million but individual outbreaks can cause economic damage that exceeds the annual average—outbreaks in Chesapeake Bay (1997) cost the Maryland seafood and recreational fishing industries almost \$50 million in just a few months.

**Cite:** Anderson, D.M.; Hoagland, P.; Kaoru, Y.; White, A.W.; *Estimated Annual Economic Impacts from Harmful Algal Bloom (HABs) in the United States*, Technical Report WHOI-2000-11 Woods Hole Oceanographic Institute, Woods Hole, Mass., p. 7.

Total public health impacts due to shellfish poisoning from HABs averaged \$22 million over a six-year interval.

**Cite:** Anderson, D.M.; Hoagland, P.; Kaoru, Y.; White, A.W.; *Estimated Annual Economic Impacts from Harmful Algal Bloom (HABs) in the United States*. Technical Report WHOI-2000-11 Woods Hole Oceanographic Institute, Woods Hole, Mass., p. 5.

Commercial fishery impacts from HABs, including wild harvest and aquaculture losses, average \$18 million per year.

**Cite:** Anderson, D.M.; Hoagland, P.; Kaoru, Y.; White, A.W.; *Estimated Annual Economic Impacts from Harmful Algal Bloom (HABs) in the United States*, Technical Report WHOI-2000-11 Woods Hole Oceanographic Institute, Woods Hole, Mass., p. 5.

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### NOTES

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## Seafood Impacts

Human sickness and death from tainted seafood resulted in lost wages, medical treatment, and investigation averaging \$22 million per year.

**Cite:** Anderson, D.M.; Hoagland, P.; Kaoru, Y.; White, A.W.; *Estimated Annual Economic Impacts from Harmful Algal Bloom (HABs) in the United States*, Technical Report WHOI-2000-11 Woods Hole Oceanographic Institute, Woods Hole, Mass., p. 5.

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### NOTES

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## Coastal Pollution and Hazardous Waste Site Impacts

More than 700 coastal hazardous waste sites have contaminated sediments in our Nation's estuaries that reduce the economic and ecological productivity of coastal resources.

**Cite:** *Coastal Hazardous Waste Site Review*, NOAA Office of Response and Restoration, NOAA, 1999.

Polluted runoff caused over 13,410 beach closings and swimming advisories in 1998.

**Cite:** *Testing the Waters 1999: A Guide to Water Quality at Vacation Beaches*, Natural Resources Defense Council (NRDC), July 1999, Table 3, "Sources of Beachwater Pollution." 2002 version is at <http://www.nrdc.org/water/oceans/ttw/titinx.asp>

NOAA has successfully recovered compensation for restoration at over 110 hazardous waste and oil spill sites around the Nation.

**Cite:** Office of Response and Restoration, NOAA Ocean Service, Policy Working Paper 02-1, May 2002.

Since 1990, NOAA has recovered over \$300 million for restoration of coastal and marine resources injured from chemical releases and oil spills.

**Cite:** *Reversing the Tide: Restoring Our Nation's Coastal and Marine Environment*, NOAA Damage Assessment and Restoration Program, 2002.

Pollution has rendered 44 percent of tested US estuaries and 12 percent of ocean shoreline waters unfit for uses such as swimming, fishing, or supporting aquatic life.

**Cite:** *Health of the Oceans Report 2002*, The Ocean Conservancy, <http://www.oceanconservancy.org/>

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### NOTES

## **Contribution to U.S. Income, Employment and Output**





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## Fisheries Contributions

The economic value added to the national economy by the commercial fishing industry is approximately \$28.6 billion yearly.

**Cite:** *Fisheries of the United States, 2001*, <http://www.st.nmfs.gov/st1/>  
(Note: Check the URL prior to quoting numbers from this website site as it gets updated annually.)

Total consumers' expenditures for fisheries products are estimated at \$55.3 billion yearly.

**Cite:** *Fisheries of the United States, 2001*, <http://www.st.nmfs.gov/st1/>

Approximately 4.3 million tons of fish were landed in the United States each year and represent an aggregate value of approximately \$4.3 billion.

**Cite:** *Fisheries of the United States, 2001*, <http://www.st.nmfs.gov/st1/>

U.S. aquaculture sales total almost \$1 billion per year, including both marine and freshwater products.

**Cite:** *Fisheries of the United States*, U.S. Commercial Landings, 2001, p. 23.

More than 17 million Americans engage in marine fishing as a recreational activity and spend approximately \$25 billion per year on fishing related activities.

**Cite:** *Fisheries of the United States, 2000*, <http://www.st.nmfs.gov/st1/>

U.S. exports of seafood products in 2001 were 2.2 billion pounds, valued at \$3 billion. The U.S. imported four billion pounds of seafood, valued at \$10.1 billion.

**Cite:** *Fisheries of the United States*, Foreign Trade Section 2001, p.60  
<http://www.st.nmfs.gov/st1/>

U.S. consumers ate an estimated 15.6 pounds of seafood per capita in 2001, making them the third largest consumer of seafood in the world.

**Cite:** *Fisheries of the United States*, Per Capita Section, 2001, p. 85 <http://www.st.nmfs.gov/st1/>

Approximately 85,000 people were employed in the seafood processing and wholesaling sectors in 2001.

**Cite:** *Fisheries of the United States, 2001*, Employment, Crafts and Plant Section, p. 95, <http://www.st.nmfs.gov/st1/>

The west coast and New England groundfish, Gulf of Mexico shrimp, swordfish, and shark fisheries can support 2,167 vessels sustainably.

**Cite:** Kirkley, James, John Ward, John Walden, and Eric Thunberg, *The Estimated Vessel Buyback Program Costs to Eliminate Overcapacity in Five Federally Managed Fisheries A Preliminary Report*, Division of Fisheries Statistics and Economics, Office of Science and Technology, NOAA Fisheries, Silver Spring, Md., June 28, 2002.

The buyback program costs for the five federally managed New England groundfish fisheries are \$999.6 million (dollars deflated to a 2002 base year), including the cost of removing latent permits.

**Cite:** Kirkley, James, John Ward, John Walden, and Eric Thunberg, *The Estimated Vessel Buyback Program Costs to Eliminate Overcapacity in Five Federally Managed Fisheries A Preliminary Report*, Division of Fisheries Statistics and Economics, Office of Science and Technology, NOAA Fisheries, Silver Spring, Md., June 28, 2002.

Forty-five percent of the 73 federally managed fisheries reviewed in seven regional reports by NOAA Fisheries are at sustainable capacities.

**Cite:** Ward, John M.; Brainerd, Theo; and Milazzo, Matteo; *Identifying Harvest Capacity and Over-Capacity in Federally Managed Fisheries, A Preliminary Qualitative Report*, Office of Science and Technology and Office of Sustainable Fisheries, Department of Commerce, National Oceanic and Atmospheric Administration, NOAA Fisheries, March, 2001.

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## NOTES

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## Coastal Contributions

In 2000-2001, the artificial and natural reefs off the four-county area of south-east Florida (Palm Beach, Broward, Miami-Dade and Monroe counties) supported almost 28 million person-days of recreational diving, fishing and viewing activities. These activities generated about \$4.4 billion in local sales, almost \$2 billion in local income, and 71,300 full and part-time jobs.

**Cite:** Johns, G.M., Leeworthy, V.R., Bell, F.W. and Bonn, M.A. *Socioeconomic Study of Reefs in Southeast Florida. Hazen and Sawyer, Final report for Broward, Palm Beach, Miami-Dade and Monroe Counties*, Florida Fish and Wildlife Conservation Commission and National Oceanic and Atmospheric Administration. October 19, 2001. Website: <http://marineeconomics.noaa.gov>

Hawaii's coral reefs generate \$360 million a year for its economy in reef-related tourism and fisheries activities, while the overall value of the state's 410,000 acres of potential reef area is estimated at \$10 billion.

**Cite:** Cesar, Herman, *Hawaii Coral Reef Initiative Research Program*, a joint program of the University of Hawaii and Department of Land and Natural Resources, 2002, Hawaii Coral Reef Initiative Research Program's web site: <http://www.hawaii.edu/ssri/hcri>.

Through innovative approaches to spill preparedness, response, damage assessments and restoration, NOAA contributes approximately \$75 million annual to the U.S. economy.

**Cite:** Office of Response and Restoration, NOAA Oceans and Coasts, Policy Working Paper 02-1 May 2002

Coastal and marine waters support 28.3 million jobs, generate \$54 billion in goods and services, contribute \$30 billion to the U.S. economy through recreational fishing, and provide a destination for 180 million Americans to recreate each year.

**Cite:** Leeworthy, Vernon R., *Preliminary Estimates from Versions 1-6: Coastal Recreation Participation, National Survey on Recreation and the Environment (NSRE)*, National Oceanic and Atmospheric Administration, NOAA Oceans and Coasts, Special Projects Office, 2000. Website: <http://marineeconomics.noaa.gov>

Travel and tourism is the Nation's largest employer and second largest contributor to the GDP, generating over \$700 billion annually. Beaches are the leading tourist destination, with coastal states earning 85 percent of all U.S. tourism revenues. Approximately 180 million people vacation and recreate along U.S. coasts every year.

**Cite:** Leeworthy, Vernon R., *Preliminary Estimates from Versions 1-6: Coastal Recreation Participation, National Survey on Recreation and the Environment (NSRE) 2000*, National Oceanic and Atmospheric Administration, NOAA Oceans and Coasts, Special Projects Office. Website: <http://marineeconomics.noaa.gov>.

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## NOTES

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## Beach Visitation

Going to the beach is a family affair, with nearly four in ten (37 percent) U.S. households visiting the beach and taking a child on the trip. Just 23 percent of overall traveling households include a child when traveling.

Nearly 110 million person-trips were made by U.S. households to the beach last year, up seven percent from the year before. A person-trip is one person traveling 50 or more miles, one-way, away from home. Households visiting the beach spend an average of \$850 per trip, excluding transportation to their destination, compared to just \$463 for overall traveling households.

More than one-third (35 percent) of beach trips last seven nights or more. On average, overnight beach trips last an average of 5.9 nights, compared to 4.1 nights for overall travel. Beach travelers are more likely than overall traveling households to stay in a condo or timeshare (16 percent vs. four percent) or in an RV (eight percent vs. five percent).

**Cite:** Coastal States Organization, *Travel Industry of America Domestic Travel Market Report, 2002*, Fish and Wildlife Service's National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

California's coastal industries contribute more than \$17 billion and 370,000 jobs to the state's economy.

**Cite:** *How Much is the Beach Worth? Calculating the Value of the Environment*, see the web site for the NOAA Coastal Services Center's magazine, Coastal Services, <http://www.csc.noaa.gov/magazine/1992/01/worth.html>.  
Note: Check the URL prior to quoting numbers from this website site as it gets updated periodically.

In the summer of 2000 (June-August), it is estimated that there was almost \$3 billion in spending on beach activities in Los Angeles and Orange counties, California. An estimated 58,600 full and part-time jobs are supported annually by beach visitors to Los Angeles and Orange county beaches.

**Cite:** Hanemann, M., Pendleton, L., and Layton, D., *Summary Report on Beach Expenditure Module*, Southern California Beach Valuation Project, Dec. 16, 2001. Website: <http://marineeconomics.noaa.gov/SCBeach/welcome.html#top>.

In 1999-2000, 12.6 million Americans age 16 and older visited California beaches, spending more than 151 million days there.

**Cite:** Leeworthy, V.R. and Wiley, P.C., *Current Participation Patterns in Marine Recreation*, Chapter in forthcoming book on the National Survey on Recreation and the Environment (NSRE), Sagamore Publishing, 2001. Website: [http://marineeconomics.noaa.gov/NSRE/NSRE\\_V1-6\\_May.pdf](http://marineeconomics.noaa.gov/NSRE/NSRE_V1-6_May.pdf). Table A-3, p. 25.

In seven estuaries alone, tourism and beach going activities generate economic benefits of more than \$16 billion to their respective regions.

**Cite:** *Natural Resources Valuation: A Report by the Nation's Estuary Program*, Environmental Protection Agency (EPA), 1997.

Economic impacts of coastal recreation impacts in Monroe County, home of the Florida Keys Sanctuary, include sales of \$1.33 billion, income of \$506 million and 21,850 jobs.

**Cite:** English, D.B.K., Kriesel, W., Leeworthy, V.R., and Wiley, P., *Economic Contribution of Recreating Visitors to the Florida Keys/Key West*. National Oceanic and Atmospheric Administration, Silver Spring, Md., 1996. p. 6 (printed), p. 10 (.pdf) Website: [http://www.srs.fs.fed.us/pubs/rpc/1998-12/rpc\\_98dec\\_12.pdf](http://www.srs.fs.fed.us/pubs/rpc/1998-12/rpc_98dec_12.pdf)

Offshore oil and gas development currently produces 22 percent of all domestically produced oil and 27 percent of natural gas. Federal royalties and taxes on offshore production average about \$4 billion per year.

**Cite:** [http://www.pewoceans.org/articles/2001/10/04/brief\\_19075.asp](http://www.pewoceans.org/articles/2001/10/04/brief_19075.asp)

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## NOTES

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## Satellites

Space-based commercial remote sensing industry sales were \$2 billion in 2001.

**Cite:** *About the Industry*, NASA/American Society of Photogrammetry and Remote Sensing (ASPRS) Market Study (NOAA-supported). Remote Sensing Industry Forecast, Powerpoint presentation, [http://www.asprs.org/asprs/news/ASPRS\\_APRIL\\_25\\_2001.ppt](http://www.asprs.org/asprs/news/ASPRS_APRIL_25_2001.ppt)

To date, 17 licenses have been granted by NOAA for the operation of 40 commercial remote sensing satellites, representing approximately \$2 billion in system investments.

**Cite:** NOAA Licensing Files, International and Interagency Office, NOAA Satellites and Information.

To date, 26 License Amendments and 20 Foreign Partnership Agreements with NOAA licensees have been approved, worth approximately \$565 million.

**Cite:** NOAA Licensing Files, International and Interagency Office, NOAA Satellites and Information.

Each year from 1980 to 1995, on average, five commercial jets encountered volcanic ash clouds in flight. About 10 percent of these encounters resulted in loss of power.

**Cite:** Kite-Powell, Hauke, *Benefits of NPOESS for Aviation—Volcanic Ash Avoidance*, Marine Policy Center, Woods Hole Oceanographic Institute (WHOI), October, 2000.

The overall economic risk from airborne volcanic ash effects historically is about \$70 million per year.

**Cite:** Kite-Powell, Hauke, *Benefits of NPOESS for Aviation—Volcanic Ash Avoidance*, Woods Hole Oceanographic Institute (WHOI), October, 2000.

The benefit from NPOESS data to volcanic ash avoidance in commercial aviation is estimated at \$10 million per year.

**Cite:** Kite-Powell, Hauke, *Benefits of NPOESS for Aviation—Volcanic Ash Avoidance*, Woods Hole Oceanographic Institute (WHOI), October, 2000.

The economic value of an operational geomagnetic storm forecasting system in the North American electricity industry is estimated at about \$450 million over three years, well above the \$100 million cost of the system.

**Cite:** Tiesberg, T. J., and Weiher, R., *Valuation of geomagnetic storm forecasts: An estimate of the net economic benefits of a satellite warning system*, Journal of Policy Analysis and Management, Vol. 19, No. 2, 2000, pages 329-334.



Collectively, the world fleet undertakes in excess of 33,000 ocean transits annually.

**Cite:** Kite-Powell, Hauke, *Benefits of NPOESS for Commercial Ship Routing—Transit Time Savings*, Marine Policy Center, Woods Hole Oceanographic Institute (WHOI), October, 2000.

The expected average annual benefit to ship routing from NPOESS data in the two decades following the launch of NPOESS in 2007 is about \$95 million per year. Because of the U.S. share of world trade, perhaps 20 percent of the total benefit—some \$20 million per year—will be realized by consumers in the United States.

**Cite:** Kite-Powell, Hauke, *Benefits of NPOESS for Commercial Ship Routing—Transit Time Savings*, Marine Policy Center, Woods Hole Oceanographic Institute (WHOI), October, 2000.

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## NOTES

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## Marine Commerce

More than 95 percent of U.S. overseas trade by volume and 37 percent by value comes and goes by ship, including nine million of barrels of imported oil daily.

**Cite:** *2000 Pocket Guide to Transportation*, U.S. Department of Transportation, <http://ntl.bts.gov/DOCS/report>.

Waterborne cargo alone contributes more than \$742 billion to the U.S. GDP and creates employment for more than 13 million citizens.

**Cite:** *An Assessment of the U.S. Marine Transportation System, A Report to Congress*, U.S. Department of Transportation, September 1999. <http://ntl.bts.gov/DOCS/report>.

Annually, the U.S. marine transportation system moves more than two billion tons of domestic and international freight; imports 3.3 billion barrels of oil to meet U.S. energy demands; supports 110,000 commercial and recreational fishing vessels that contribute \$111 billion to state economies.

**Cite:** *An Assessment of the U.S. Marine Transportation System, A Report to Congress*, U.S. Department of Transportation, September 1999. <http://ntl.bts.gov/DOCS/report>.

Every year, 134 million passenger day trips are ferried to work and other destinations on U.S. waterways, along with five million cruise ship passengers.

**Cite:** *Maritime Transportation System Report to Congress*, 1999, p. vii, Executive Summary. Website: <http://www.dot.gov/mts>.

The Maritime Transportation System ships 48 percent of the oil needed to meet U.S. energy demands.

**Cite:** Energy Information Administration, Annual Energy Review 2001. Website: <http://www.eia.doe.gov/emeu/aer/contents.html>.

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## Coastal Ocean Observing Systems

Reducing the risk of marine accidents, improving search and rescue, commercial fishing, and recreational boating by providing coastal information and services could be worth over \$30 million annually in the Gulf of Maine. Extrapolating benefits to all regions of the U.S. coasts are likely to be greater than \$300 million annually.

**Cite:** Kite-Powell, H. and Colgan, C., *The Potential Economic Benefits of Coastal Ocean Observing Systems: The Gulf of Maine*, NOAA, Office of Policy and Strategic Planning, Washington, D.C., December, 2001.

The annual economic return to the U.S. economy of NOAA's El Niño ocean observing and forecast system is between 13 and 26 percent, which is significantly higher than the Office of Management and Budget's 5.8 percent minimum rate of return specified for Federal projects.

**Cite:** Sassone, P., and Weiher, R., *Cost-Benefit Analysis of TOGA and the ENSO Observing System*. In R. Weiher (ed.) *Improving El Niño Forecasting: The Potential Economic Benefits*, NOAA, Office of Policy and Strategic Planning, 1999. p. 47.

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### NOTES

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## Weather, Climate and Storm Warnings

Weather derivatives are financial contracts in which money changes hands based on seasonal average temperatures, degree days, or precipitation amounts. According to the Weather Risk Management Association (WRMA 2002), the total notional value of seasonal weather derivatives executed between parties has been about \$2 billion per year in 1998-2000 and \$4 billion in 2001. This has resulted in a total notional value of \$11.8 billion in weather risk management contracts over the past five years.

**Cite:** Dutton, John A., *Opportunities and Priorities in a New Era for Weather and Climate Services*, Bulletin of the American Meteorological Society, September 2002, pp 1303-1311. WRMA, 2002: Second annual industry survey. Website: [www.wrma.org](http://www.wrma.org).

The size of the Private/Commercial Meteorological value added sector is estimated to be approximately \$400-700 million in annual gross receipts, with the number of firms estimated at 400, most of which are sole proprietorships, and employment of approximately 4,000 people.

**Cite:** Commercial Weather Services Association

NOAA's National Weather Service forecasts, warnings, and the associated emergency responses result in a \$3 billion savings in a typical hurricane season. Two-thirds of this savings, \$2 billion, is attributed to the reduction in hurricane-related deaths, and one-third of this savings, \$1 billion, is attributed to a reduction in property-related damage because of preparedness actions.

**Cite:** Dr. Hugh Willoughby, HRD/AOML, *Costs and Benefits of Hurricane Forecasts*, minutes of 55th Interdepartmental Hurricane Conference, 5-9 March 2001, Orlando, FL.

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The largest single customer of NOAA products are the 105 million U.S. households who consult the daily forecast at least once a day. The NOAA National Weather Service's annual budget is about \$1,383 million. The average U.S. household, therefore pays about \$13 a year for NOAA's weather services.

A detailed National survey using different stated preference nonmarket valuation approaches to elicit household values for both current and improved weather forecast services revealed:

- the average value of all current weather forecast information from public and private sectors is approximately \$109 per household, with a total national value of \$11.4 billion per year.
- the annual value of improving the daily forecast in terms of more accurate one-day and multi-day forecasts, geographic detail, and frequency of updates is \$16 per household, or \$1.73 billion per year.

Total annual Federal spending for weather information is about \$25 per household (including aviation and defense, in addition to NOAA), which produces an annual benefit-cost ratio of 4.4 to one to U.S. households alone, or net national benefits of \$8.8 billion a year. This does not include benefits in agriculture, transportation, construction, or benefits to households in other countries that rely on weather information from the U.S.

**Cite:** Lazo, J. and Chestnut, L., *Economic Value of Current and Improved Weather Forecasts in the U.S. Household Sector*, report prepared for NOAA's Chief Economist by Stratus Consulting, Boulder, Colo., November 2002.

Reducing the length of coastline under hurricane warnings saves at least \$640,000 per coastal mile in costs of evacuations and other preparedness actions. (Note: Per mile evacuation costs are highly variable with reports in the literature varying from under \$100,000 to \$1 million. This estimate must be applied with great care, especially in program evaluation.)

National implementation of the Advanced Hydrologic Prediction Service (AHPS) will save lives and an estimated \$240 million per year in flood losses, and will contribute an additional \$520 million per year in economic benefits to water resources users.

**Cite:** *Use and Benefits of the NWS River and Flood Forecasts*, National Hydrologic Warning Council, April 1, 2002.

Better preparation, response, and mitigation will reduce the average cost (\$500 million per event) of storm-related disasters by 10 percent (\$50 million per event). A 10 percent reduction in the cost of storm-related disasters means a \$700 million in savings per year (with an average 14 events saving \$50 million each per year).

**Cite:** *Evaluation of Erosion Hazards*, H. John Heinz III Center for Science, Economics, and the Environment, Washington, DC, April 2000.

Economists have quantified the benefits of improved El Niño forecast in various sectors:

- Benefits to U.S. agriculture by altering planting decisions have been estimated at \$265-300 million annually, throughout El Niño, normal, and La Niña years.
- Similarly, benefits to Mexican agriculture range from \$10 to \$25 million annually.
- Benefits in U.S. corn storage could approach \$200 million annually.
- Even in a small Northwest Coho salmon fishery, annual benefits are estimated in \$250,000 to \$1 million.
- Worldwide agriculture benefits of better El Niño forecasts are at least \$450 to \$550 million per year.
- An analysis of NOAA's operational El Niño forecasting system comparing forecast systems costs with anticipated benefits in just the U.S. agriculture sector yielded an estimated annual rate of return on that investment of between 13 to 26 percent.

**Cites:** Weiher, Rodney, ed. *Improving El Niño Forecasting: The Potential Economic Benefits*, NOAA, U.S. Department of Commerce, 1997, p. 29, p. 41, p. 43, p.47, for U.S. Agriculture, Corn Storage, Fisheries and Operational Forecast System respectively.

Adams, R.M.; Houston, L.L.; McCarl, B.A.; Tiscareno, M.L.; Matus, J.; and Weiher, R.F., *The Benefits to Mexican Agriculture of an El Niño Southern Oscillation (ENSO) Early Warning System*, Journal of Agricultural and Forest Meteorology, 2002 (inpress).

McCarl, B., and Kim, M., *The Value of El Niño and NAO Information in Worldwide Agriculture*, Working Paper, Department of Agriculture Economics, Texas A&M University, College Station, Texas.

NOAA Satellites and Information's Air-Freezing Index (AFI) reduces construction costs by \$330 million per year and saves an equivalent of 8.6 million gallons of heating fuel.

**Cite:** *Economic Value for the Nation*, NOAA Satellites and Information, September 2001.

A Heat Watch/Warning System used in Philadelphia since 1995 is estimated to have saved 117 lives over its first three years of operation. The total dollar benefits of this system are estimated to be \$468 million, while costs are on the order of \$200,000, for this three year period. Philadelphia is one of 10 such systems running in the U.S. and three additional in other countries.

**Cite:** Teisberg, T., Ebi, K., Kalkstein, L., Robinson, L., and Weiher, R., *Heat Watch/Warning Systems Save Lives: Estimated Costs and Benefits for Philadelphia 1995-1998*, draft submitted to Bulletin of the American Meteorological Society, 2002.

For every \$1 that energy companies spend in acquiring NOAA climate station data, they receive a potential benefit of saving \$495 in infrastructure costs that would be required to maintain their own climate data base storage, archiving, and reporting system. Extrapolating the savings to the entire U.S. energy market yields a potential benefit of \$65 million.

**Cite:** *Investigating the Economic Value of Selected NESDIS Products*, Centrec Consulting Group, LLC, January, 2003.

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## Defense

The “Long Range Weather Forecasting Support of Energy Use at Navy Activities” (LRF) program has documented in excess of \$60 million of savings over the past 15 years.

**Cite:** Chief of Naval Operations Memorandum, 20 April 1998.

A decision to relocate the Norfolk harbor fleet could cost \$5 million and require 72 hours advance notice. This includes costs to recall personnel and make ready ships in maintenance or being overhauled. It costs \$17 million to move all of the Navy’s ships along the east coast out of port.

**Cite:** International Hurricane Conference 2001 meeting presentation.

During Hurricane Floyd in 1999, the Command’s early warning gave the Atlantic Fleet sailors time to move 82 ships and submarines out of harms way. The sortie costs the Navy over \$17 million, but a decision to not sortie may have resulted in billions of dollars in damages.

**Cite:** *Navy Promotes Hurricane Awareness*, News Release from the Naval Meteorology and Oceanography Command, June 16, 2000.

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## Sea Grant

The Sea Grant training program at 5,000 seafood processing plants will prevent 20,000 to 60,000 seafood-related illnesses a year, which could cost consumers as much as \$115 million annually.

**Cite:** *U.S. FDA and National Sea Grant College Program Biennial Report*, 1998-99.

In North Carolina, 200 of the 205 new oceanfront homes built to the Sea Grant hurricane standards survived Hurricane Fran in 1996, compared more than 500 older oceanfront houses in the same area that were destroyed.

**Cite:** *National Sea Grant College Program Fact Sheet*, August 2001.

Sea Grant research and outreach on Manila clams and blue mussels have resulted in new industries worth \$19 million annually.

Sea Grant research and extension work for hybrid striped bass aquaculture has expanded this species from being a demonstration project ten years ago to a \$25 million dollar annual business.

No mussel culture industry existed in the Northeast prior to 1980 and after a five-year Sea Grant research effort landings of wild and farmed mussels are now valued at \$6 million.

**Cite:** *Science Serving the 21st Century*, National Sea Grant Program, Publication OHSU-B-053, March 1999, page 2.

Sea Grant research efforts to develop new drugs from marine organisms have resulted in discovery and description of more than 1,000 compounds that may be vitally important to the health industry.

Efforts to develop state designated underwater preserves have led to new diving activity in Great Lakes coastal communities providing an economic stimulus of at least \$1.5 million over a two-year period.

Results of Sea Grant studies on sewage effluents and coastal systems allowed Orange County, California to receive secondary treatment waivers saving taxpayers as much as \$50 million.

Research on modification of salmon gillnets prevented closure of Puget Sound sockeye salmon fishery saving hundreds of jobs and millions of dollars.

**Cite:** *Science Serving America's Coast—Three Decades of Impacts*, National Sea Grant Association, February, 2002. Available online at [http://www.sga.seagrant.org/pdfs/sga\\_impacts\\_fs.pdf](http://www.sga.seagrant.org/pdfs/sga_impacts_fs.pdf)

## **Values and Uses of Coastal Ocean Natural Resources**



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## Coastal Uses

Currently, more than half of the U.S. population—141 million people—reside within 50 miles of the coast, which occupies only 11 percent of the land area of the lower 48 states.

**Cite:** Bookman, Charles A., Culliton, Thomas J., and Warren, Maureen A., *Trends in U.S. coastal regions, 1970-1998: addendum to the proceedings, Trends and future challenges for U.S. national ocean and coastal policy*, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, NOAA Oceans and Coasts, Special Projects Office, Silver Spring, Md., 1999. Also available online at [http://www.nos.noaa.gov/Products/retiredsites/natdia\\_pdf/trends\\_addendum.pdf](http://www.nos.noaa.gov/Products/retiredsites/natdia_pdf/trends_addendum.pdf)

Over the next 15 years, coastal population is projected to increase by 24.7 million people, reaching 166 million people by the year 2015.

**Cite:** Bookman, Charles A., Culliton, Thomas J., and Maureen A. Warren, *Trends in U.S. Coastal Regions, 1970-1998 : Addendum to the Proceedings, Trends and Future Challenges for U.S. National Ocean and Coastal Policy*, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, NOAA Oceans and Coasts, Special Projects Office, Silver Spring, Md. 1999. Also available online at [http://www.nos.noaa.gov/Products/retiredsites/natdia\\_pdf/trends\\_addendum.pdf](http://www.nos.noaa.gov/Products/retiredsites/natdia_pdf/trends_addendum.pdf)

In 1999-2000, over 43 percent of the civilian population 16 years and older participated in at least one of the 19 marine outdoor recreation activities, which translates into over 89 million participants.

**Cite:** Leeworthy, Vernon R., *Preliminary Estimates from Versions 106: Coastal Recreation Participation, National Survey on Recreation and the Environment (NSRE)*, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, NOAA Oceans and Coasts, Office of Ocean Resources Conservation and Assessment 1997. Also available online at <http://marineeconomics.noaa.gov/SocmonFKI/publications/97-30.pdf>

U.S. coastal counties are growing three times faster than counties elsewhere in the country. This population is expected to increase by an average of 3,600 people per day, reaching 165 million by the year 2015. Across the United States, development is increasingly concentrated along the coast, with about 820,000 new homes constructed in coastal areas every year, and more than half of all new industrial, office, retail and recreational building.

**Cite:** Creason, J., Kadri, J., Serenbetz, G., Warziniack, T., *Economic Profiles for EPA's National Estuary Program*, 2002. Also available online at <http://www.epa.gov/owow/estuaries/about1.htm>

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## Nonmarket Coastal Benefits

Nonmarket coastal resource values in the Channel Islands area of southern California for the protection of Bald eagles, Peregrine falcons, White croaker and Kelp bass amounts to over \$575 million (1994 dollars).

**Cite:** *Prospective Interim Lost Use Value Due to DDT and PCB Contamination in the Southern California Bight*, Natural Resource Damage Assessment, Inc., La Jolla, Calif., September, 1994.

To prevent oil spills off the coast of Central California over a 10 year period, Californians would be willing to pay \$75 per household.

**Cite:** *The Value of Preventing Oil Spill Injuries to Natural Resources along California's Central Coast*, Natural Resource Damage Assessment Inc., San Diego, Calif., March, 1996.

Prevention of another major oil spill similar to the *Exxon Valdez* is valued at approximately \$3 billion to the U.S. public (1990 dollars).

**Cite:** *A Contingent Valuation Study of Lost Passive Use Values Resulting from the Exxon Valdez Oil Spill*, Natural Resource Damage Assessment, Inc., La Jolla, Calif., November, 1992.

Recreation use values for three southern California beaches (1989) include annual nonmarket values of \$360 million and an asset value of \$12 billion.

**Cite:** U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Ocean Resource Conservation and Assessment, Strategic Environmental Assets Division.

In 2000-2001, annual nonmarket recreation values for the artificial and natural reefs of southeast Florida by both residents and visitors was estimated at \$312 million and an asset value of \$10.4 billion.

**Cite:** Johns, G.M., Leeworthy, V.R., Bell, F.W., and Bonn, M.A., *Socioeconomic Study of Reefs in Southeast Florida*, Hazen and Sawyer, Final Report for Broward, Palm Beach, Miami-Dade and Monroe Counties, Florida Fish and Wildlife Conservation Commission, Florida State University and National Oceanic and Atmospheric Administration. October 19, 2001. Online at: [ftp://spo.nos.noaa.gov/publications/spol/1\\_5FSPO\\_5F02-01/02-01.pdf](ftp://spo.nos.noaa.gov/publications/spol/1_5FSPO_5F02-01/02-01.pdf) and <http://marineeconomics.noaa.gov/pubs/welcome.html>.